TRUNKING

Principles of operation

Control channels

In essence, a trunked radio system is a packet switching computer network. Users' radios send data packets to a computer, operating on a dedicated frequency — called a Control Channel — to request communication on a specific talk-group. The controller sends a digital signal to all radios monitoring that talkgroup, instructing the radios to automatically switch to the frequency indicated by the system to monitor the transmission. After the user is done speaking, the users' radios return to monitoring the control channel for additional transmissions.

This arrangement allows multiple groups of users to share a small set of actual radio frequencies without hearing each others' conversations. Trunked systems primarily conserve limited radio frequencies and also provide other advanced features to users.

Comparison with telephone trunking

The concept of trunking (resource sharing) is actually quite old, and is taken from telephone company technology and practice. Consider two telco central office exchanges, one in town "A" and the other in adjacent town "B". Each of these central offices has the theoretical capacity to handle ten thousand individual telephone numbers. (Central office "A", with prefix "123", has available 10,000 numbers from 123-0000 to 123-9999; central office "B", with prefix "124", the same.)

How many telephone lines are required to interconnect towns A & B? If all 10,000 subscribers in "A" were to simultaneously call 10,000 subscribers in "B", then 10,000 lines, (in telco parlance "trunk lines", or simply "trunks") would be required between the two towns. However, the odds of that happening are remote. Telephone companies have well-proven formulas which predict the optimal number of trunk lines actually needed, under normal conditions, to interconnect two telephone exchanges.

This concept has simply been applied to radio user groups, to determine the optimal number of channels needed, under normal conditions, to accommodate given number of users. In the event of a widespread emergency such as a major earthquake, many more users than normal will attempt to access both the telephone and radio systems. In both cases once the trunking capacity of the systems is fully used, all subsequent users will receive a busy signal.

In our example of police dispatch, different talk-groups are assigned different system priority levels, sometimes with "preempt" capability, attempting to ensure that communication between critical units is maintained.

Differences from conventional two-way radio

"Trunked" radio systems differ from "conventional" radio systems in that a conventional radio system uses a dedicated channel (frequency) for each individual group of users, while "trunking" radio systems use a pool of channels which are available for a great many different groups of users.

For example, if police communications are configured in such a way that twelve conventional channels are required to permit citywide dispatch based upon geographical patrol areas, during periods of slow dispatch activity much of that channel capacity is idle. In a trunked system, the police units in a given geographical area are not assigned a dedicated channel, but instead are members of a talk-group entitled to draw upon the common resources of a smaller pool of channels.

Advantages of trunking

Trunked radio takes advantage of the probability that with any given number of user units, not everyone will need channel access at the same time, therefore fewer discrete radio channels are required. From another perspective, with a given number of radio channels, a much greater number of user groups can be accommodated. In the example of the police department, this additional capacity could then be used to assign individual talk groups to specialized investigative, traffic control, or special-events groups which might otherwise not have the benefit of individual private communications.

To the user, a trunking radio looks just like an "ordinary" radio: there is a "channel switch" for the user to select the "channel" that they want to use. In reality though, the "Channel switch" is NOT switching frequencies as in a conventional radio but when changed, it refers to an internal software program which causes a talkgroup affiliation to be transmitted on the control channel. This identifies the specific radio to the system controller as a member of a specific talkgroup, and that radio will then be included in any conversations involving that talkgroup.

This also allows great flexibility in radio usage - the same radio model can be used for many different types of system users (IE. Police, Public Works, Animal Control, etc.) simply by changing the software programming in the radio itself.

Trunked radio systems also provide a small level of extra privacy since the talkgroups are constantly transmitting on different frequencies. This makes it difficult for a scanner listener without a programmed trunk tracking scanner to keep up with the conversation.

Motorola Trunked Radio

From Wikipedia, the free encyclopedia

Types

- Type I
- Type II
- Type IIi Hybrid
- Type II SmartZone
- Type II SmartZone OmniLink
- Type II VOC

Motorola Type I and Type II systems achieve the same thing in a slightly different way. One important distinction between these systems is the amount of data transmitted by each radio when the operator pushes the PTT button. A Type I system transmits the radio's ID, its fleet information, and the subfleet information. A Type II system only transmits the radio's ID.

What's the difference? In Type I systems, each radio in the trunk group individually transmits its own affiliation. In Type II systems the trunk system maintains a database that determines each radio's affiliation.Another difference between the systems is that Type I systems are arranged in a fleet-subfleet hierarchy. For example, it is possible for a city using a Type I system to designate four fleets, each with eight subfleets. The police department, fire department, utilities group, and city administration could each be a separate fleet. The police might decide to further divide its fleet into subfleets, such as dispatch, tactical operations, detectives, north, south, east and west side patrols and supervisors. All the available police radios would then be assigned to one of the police subfleets, letting the police centralize their communications and control the type of users on a single system. Determining the exact fleet-subfleet hierarchy for a particular area is referred to as fleet map programming.

The disadvantage of a Type I system is that the brief burst of data sent when a user transmits must contain the radio's ID, its fleet information, and the subfleet information as well. This is three times the amount of data a Type II system radio sends. Since the data capacity of Type I systems is limited, and the total amount of data increases with each user, Type I systems usually accommodate fewer users than Type II systems. Nevertheless, Type I systems are still in use.

Digital Voice Types

- ASTRO - proprietary VSELP vocoder implemention and IMBE vocoder implementation for APCO-25 Common Air Interface

Motorola Type I

Motorola Type I Is the original type of Motorola's Trunked radio system; it is based on Fleets and Subfleets. Each system had a certain number of Fleets assigned, and then each Fleet had a certain number of Subfleets and radio IDs. The distribution of Fleets and Subfleets on a Type I system is determined by the system Fleetmap. Motorola Type I systems are not scalable because they limit the amount of IDs any fleet or subfleet can support. Each Type I ID appears as a three or four digit number, followed by a hyphen, followed by a one or two digit number (example 200-14).

The term "Privacy Plus" refers to a Type I system. Privacy Plus systems are normally older public safety systems and SMRs.

Motorola Type II

Motorola Type II refers to the second generation Motorola Trunked radio systems that replaced fleets and subfleets with the concept of talkgroups and individual radio IDs. There are no dependencies on fleetmaps, therefore there are no limitations on how many radio IDs can participate on a talkgroup. This allows for greater flexibility for the agency. When scanning Motorola IDs, each Type II user ID appears as an even 4- or 5-digit number without a dash (example 2160).

With the introduction of Type II, the System ID was also introduced. This is a 4 digit identifier that is unique to each trunking system. The purpose of the System ID is to allow radios to operate only on that specific system, and to identify each system. The System ID also allows for enhanced security because a radio now requires a System Key, unique to the System ID in order to be programmed onto any given system. Type I systems do not use unique System IDs, thus the possibility exists for overlapping coverage in busy areas.

The term *SmartNet* refers to a set of features that make Motorola Type I and II trunked systems APCO-16 compliant. These include better security, emergency signaling, dynamic regrouping, remote radio monitoring, and other features.

The following is true of a Type II SmartNet system:

- Up to 28 system channels
- Up to 65,534 unique radio ids
- Up to 4,094 talkgroups
- Use of odd-numbered talkgroups
- Priority Scanning of talkgroups

Status Bits

Type II SmartNet systems uses status bits for special transmissions such as Emergency, Patches, DES/DVP scrambled transmissions, and Multiselects on Motorola Trunking systems. Motorola Trunking radios directly interpret these status bits for their special functions, therefore no difference is noticed by the user. The Trunktracker Scanner, however, interpret these special talkgroup status bits as different talkgroups entirely. Below is the conversion chart for these special status bits:

```
Dec ID + #      Usage
-------------------------------------------------------
ID+0            Normal Talkgroup
ID+1            All Talkgroup
ID+2            Emergency
ID+3            Talkgroup patch to another
ID+4            Emergency Patch
ID+5            Emergency multi-group
ID+6            Not assigned
ID+7            Multi-select (initiated by dispatcher)
ID+8            DES Encryption talkgroup
ID+9            DES All Talkgroup
ID+10           DES Emergency
ID+11           DES Talkgroup patch
ID+12           DES Emergency Patch
ID+13           DES Emergency multi-group
ID+14           Not assigned
ID+15           Multi-select DES TG
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Therefore, if a user was transmitting a multi-select call on talkgroup 1808, the trunktracker would actually receive those transmissions on 1815. Some common uses of these status bits are as follows:

- When a user hits their emergency button, all conversations on the talkgroup revert to the emergency status talkgroup (ID+2) until the dispatch clears the emergency status. Therefore, if someone hit their emergency button and their radio was on talkgroup 16, all communications would switch to talkgroup 18.
- When an emergency is declared, the system automatically strips any patches present on the talkgroup and places the talkgroup in emergency with +2 and any patched talkgroups as a Multiselect (+7) with the console repeating subscriber audio from the talkgroup in emergency.
- A lot of Fire and EMS departments dispatch tone-outs and alarms as Multi-select communications (ID+7). Therefore, if your fire department dispatch talkgroup is 1616, and they do dispatch tone-outs and alarms as Multi-selects, then those communications will be on talkgroup 1623.

This can be a problem, because you will miss communications if you don't have those talkgroups programmed. By setting the Type II block you are monitoring with a fleetmap of S-1 (Mot Size A), you'll essentially get Type I subfleets for each Type II talkgroup - encompassing all of the status bits into one subfleet. Some scanners also allow you to disable the status bit information so that you will always see the ID+0 regardless of the status of the talkgroup.

SmartNet systems also added a scanning feature, called "Priority Monitor," which permitted priority scanning of talkgroups. The subscriber radio has the choice of selecting two priority talkgroups (one high and one low priority in addition to eight non-priority talkgroups). When the radio is in the middle of a voice call it is continually receiving sub-audible data on the voice channel indicating the talkgroup activity on the other channels of the system. If a talkgroup ID appears which is seen as a higher priority than the active call, the radio will switch back to the control channel to look for the late entry data word indicating which channel to tune to.

This voice channel sub-audible datastream has a limitation in the number of bits it can use to represent a talkgroup ID. Because of this the last digit of the talkgroup ID (right-most) is removed. The radio then presumes any ID it receives is an odd-numbered talkgroup ID. This is the reason behind odd numbering of talkgroups on SmartNet systems. If the systems administrator assigned odd AND even numbered talkgroups there would be a lot of confusion with the Priority Monitor feature when reading the data over the voice channel. This was a problem with the Radio Shack PRO-92 as it used only the sub-audible data to track trunked systems.

Motorola Type II SmartZone

SmartZone systems are composed of Type II SmartNet systems that are networked together via microwave or land-line data circuits to provide multi-site wide-area communications. Many large public safety and state agencies use SmartZone systems for wide-area communications. Each individual trunked system is considered a site, or a sub-system if you are considering a Simulcast system, and is controlled by the Zone Controller, which is the master controller for all activity and is where all network links terminate. The primary types of sites are 6809 (named after the type of microprocessor used, and can be single or simulcast configurations), MTC 3600 (introduced to take the place of the 6809, and named for the speed of the control channel data stream in baud), and IntelliRepeaters (single-site only, a type of controllerless site). SmartZone allows efficient use of channels at each site by feature called "Dynamic Site Assignment", or DSA. DSA's simple purpose is to determine whether a site actually needs to broadcast a call or not. In order to make this feature work subscriber radios are required to affiliate, or send in their radio identification and selected talkgroup information whenever they power-up, change channels, or change sites. A programmable "timeout" can be set to automatically query any given radio to determine its affiliation status on the network. These affiliations are compiled into a table which the Zone Controller maintains. When a call is requested at a site, the Zone Controller determines which site that talkgroup is registered at and routes that audio via a switch, referred to as the Ambassador Electronics Bank (AEB), to the appropriate channel at the site. SmartZone allows seamless roaming between sites that is transparent to the user. To the user, the system, when properly configured, appears as just one large system, when in fact the user is actually roaming between several different sites at different locations.

The characteristics of a Motorola SmartZone system are similar to SmartNet systems with the following changes:

- Up to 28 channels per site
- Up to 64 sites (older Zone Controller versions were limited to 48)
- Analog and/or digital voice and/or analog/digital encryption

Monitoring a SmartZone system with a trunktracking scanner is the same process as monitoring any other Type II SmartNet system, except that you can only monitor one site at a time. For you to monitor a specific talkgroup on a SmartZone site, a system users radio must be affiliated to that specific site. Therefore, if you are monitoring talkgroup "POLICE-NORTH" on a site with no affiliated radios on that talkgroup, then you will not hear any communications on that talkgroup on that site.

The new MZC 3000 SmartZone Zone Controller introduced an Ethernet based connection point for sites, consoles, data broadcast boxes, and C/DIUs. This Zone Controller supports 64 sites in addition to the other pieces of hardware that previously limited the number of sites as the connection ports were shared.

Motorola Type II SmartZone OmniLink

Type II SmartZone OmniLink is a type of Trunked radio system with multiple sites, providing a broad range of robust system features and utilizing a distributed call processing architecture linking up to four multi-site systems together into one seamless network, supporting up to 192 sites. Typical users of SmartZone OmniLink systems include organizations who have vast geographic requirements such as electric and gas utilities and extremely large public safety agencies.

Each Zone in an OmniLink network is considered its own SmartZone network, with its own unique system ID, and is controlled by its own Zone Controller. Radios can be permitted or restricted to roam from one Zone to another. The OmniLink infrastructure permits each Zone Controller to communicate and coordinate these roaming actions. (This is similar to cellular networks and roaming onto another carrier's network)

Motorola Type II VOC

The introduction of Motorola Type II SmartZone introduced the IntelliRepeater. An IntelliRepeater, or IR, site is a bare-bones trunked site which has no database of users or talkgroups. It is simply sophisticated software running on a Quantar repeater. It is meant to be controlled by the Zone Controller and to be commanded as to who has permission and who does not. There are some very basic restrictions in the event Site Trunking (a site loses its link to the Zone Controller) does occur but for all intents and purposes once an IR site is in Site Trunking mode it's a free-for-all site.

IR sites are generally used for a small geographic area or to fill in holes. For sites that are used to fill in coverage traffic is very limited. To allow as limited a number of channels for use, and to be spectrum efficient, Voice On Control (VOC) was developed to permit the control channel to temporarily act as a voice channel. This allows as little as one channel per site, but access must be severely restricted to the site or communication problems will occur.

When all channels at a VOC enabled site are in use, or a single channel site gets a call request, there is specific data sent out over the control channel to notify all radios at the site that the control channel will be momentarily switching to voice channel mode. Once this happens radios resort to their programmed information which contains timing values that determine what to do once the timer runs out and there is still no control channel (Signal "Out of Range," switch sites, etc.) available.